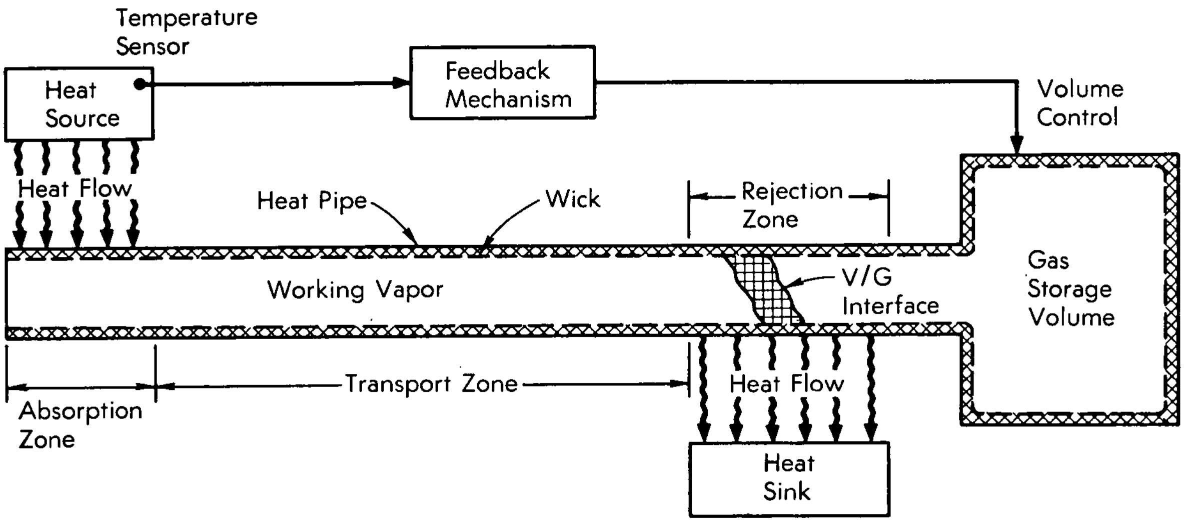
NASA TECH BRIEF
Ames Research Center

Feedback Control of Variable Conductance Heat Pipes

The results of theoretical studies suggest that the performance of variable conductance heat pipes used to regulate the temperature of a heat source can be improved by introduction of a feedback loop. Preliminary designs have been completed for two different approaches to implement such a loop; one uses a passive feedback system and the other uses an active feedback system.



The variable conductance pipe tends to maintain its own temperature constant by extracting heat from the source, thereby maintaining the temperature of the source within limits. However, it will allow the temperature of the heat source to vary greatly if a high thermal impedance exists between the source and the pipe. Wide fluctuations in energy transport requirements or in sink temperature will also adversely affect the temperature regulation of the source, and regulation suffers if mass diffusion of vapor into the gas storage volume can occur. Under any of these conditions, a feedback that is keyed to the source temperature can effectively improve control of the source temperature.

The typical variable conductance heat pipe is a long, thin, sealed tube with an expanded region at the cooling end to act as a storage volume for a noncondensable gas, as shown in the figure. The vapor/gas interface is located somewhere in the heat rejection zone. The condensable working fluid moves from the heat absorption zone to the rejection zone as a vapor, and is returned as a liquid by the capillary action of the wick lining the inside of the pipe.

In principle, the feedback system monitors the source temperature and makes necessary changes of the area available for heat rejection by adjusting the

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storage volume of the noncondensable gas and, hence, the position of the vapor/gas interface. For example, when the feedback system senses an increase in source temperature, the control action is such that the vapor/gas interface is caused to move downstream away from the evaporator, thus increasing the heat rejection area.

The passive feedback system which has been designed employs an extensible bellows as a storage volume. The feedback medium is an enclosed body of incompressible fluid that extends from a temperature-sensing bulb at the heat source through a slim tube to a second bellows attached to the first. Temperature changes at the source cause volume variations of the medium which are coupled through the bellows to adjust the effective cooling area.

The active feedback system is comprised chiefly of an electronic temperature sensor, an electronic controller, and an electrical device to heat the storage volume. Extension of the wick into the storage volume assures the presence of saturated vapor mixed with the noncondensable gas at all times. Volumetric response of this mixture to temperature variation is much sharper than that of dry gas alone and, at the same time, mass diffusion is controlled. When the source temperature is too low, heat is applied to the storage volume; this results in a motion of the vapor/gas interface in the direction which reduces the effective thermal rejection area. Consequently, the energy transport function of the pipe is reduced and the source temperature is allowed to rise. Stability analyses made for both of these designs and for the general case showed that a stable system can always be achieved. A mathematical model has been developed in functional form to treat the various methods for obtaining thermal control; it may be applied to a wide variety of configurations.

Notes:

1. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)
   Reference: NASA CR-73475 (N71-15602), Study to evaluate the Feasibility of a Feedback Controlled Variable Conductance Heat Pipe.

2. No additional documentation is available. Specific questions, however, may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B 72-10169

Patent status:

No patent action is contemplated by NASA.

Source: Walter B. Bienert of
Dynatherm Corporation
under contract to
Ames Research Center
(ARC-10460)